Central Bank transparency and the U.S. interest rates level and volatility response to U.S. news

TUYSUZ, Sukriye

BETA

15 September 2007

Central Bank transparency and the U.S. interest rates level and volatility response to U.S. news

Sukriye Tuysuz*

Abstract

This paper investigates the impact of U.S. macroeconomic and monetary news on market interest rate level and volatility. These news relate to Federal Reserve System (FED) target variables and unexpected policy rate changes. It examines whether the fact that FED announces its policy rate decisions immediately after each Federal Open Market Committee (FOMC) meeting alters the market rate response. These meetings occur regularly at scheduled time since February 1994. It also checks if this transparency measure (i.e. announcing the policy rate immediately after the meetings and regularly at scheduled time) has increased the predictability of FED's rates by the market. The results reveal that after 1994, financial markets can better foresee monetary policy decisions compared to the period when the policy rate was announced with a delay of 45 days after the meetings. Moreover, U.S. interest rate volatility is less affected by the announcements on FED target variables after 1994. In the same way, unexpected monetary policy decisions influence less interest rate level. These results suggest that, in accordance with theory, a greater transparency improves market participants' understanding of the Federal Reserve's monetary policy reaction function. Interestingly, the date on which FED announces the policy rate decision has a greater impact on U.S. interest rate volatility after 1994. This observation suggests that the FED's credibility might have decreased after 1994. However, it is not related to the immediate diffusion of policy rate decisions.

JEL Classification: E43; E44; E48

keywords: Monetary policy, news announcements, transparency, term structure of interest rates, EGARCH

*BETA-THEME, Université Louis Pasteur, Department of Economics, 61 avenue de la forêt noire, 67000 Strasbourg, France, tuysuz@cournot.u-strasbg.fr

1 Introduction

Aside from its negative effect on the conduction of monetary policy by the central bank[1], high interest rate volatility blurs the prevision of the monetary policy stance by financial market participants. In order to provide a stable environment for financial market which facilitates to reach its target, central banks seek to reduce interest rates variability (Goodfriend, 1990; Froyen and Waud, 1995; Goodhard, 1996; Woodford, 1999)[2,3]. Indeed, it is easier for the policy makers to reduce the uncertainty that they create themselves rather than the uncertainty due to other factors.

Since the early 90s, most of the central banks in industrial countries have adopted several measures aiming to improve the transparency of their policy actions. The Federal Reserve Bank (FED), for example, has changed the way it conducts monetary policy and the way it communicates monetary policy changes to the public in order to improve transparency (Blinder, 1998; Blinder *et al.*, 2001). The FED decision of announcing its policy rate immediately after each Federal Open Market Committee (FOMC) meeting, in February 1994, can be considered as an example of these measures. Greater information about how a central bank makes policy decisions helps to reduce financial speculation, reduce markets operators expectations about future monetary authorities decisions and future evolution of the central bank target variables and then reduce market volatility. The purpose of the present paper is to check if a greater transparency enables to reduce market volatility by reducing the effect of macroeconomic and monetary news concerning the monetary policy on interest rate volatility.

Several empirical studies have examined the effect of a greater transparency on interest rate levels response to news related to monetary policy[4]. For instance, Sellon and Weiner (1996), Kuttner (2001) and Urich and Wachtel (2001) notice that a greater disclosure allowed to reduce U.S. interest rates response to FED actions. In the same way, Gravelle and Moessner (2001) and Par-

[1] Interest rates instability influences the economic situation and central bank target variables and then importunes the monetary policy conduct.

[2] Central bankers job is to conduct monetary policy in order to promote price stability, sustainable growth, and a stable financial system.

[3] There have been a number of papers documenting and analysing the so-called "interest rate smoothing" (Goodhart, 1996; Woodford, 1999). See Sack and Wiedland (2000) for a reviews of the literature. Although the primary focus of that literature is the observed tendency for the smoothing of policy rates, part of the motivation for such behavior has been to provide a stable environment for financial markets.

[4] See for example Sellon and Weiner (1996), Muller and Zelmer (1999), Haldane and Read (2000), Clare and Courtenay (2001), Gravelle and Moessner (2001), Urich and Wachtel (2001), Kuttner (2001), Parent (2003) and Coppel and Connolly (2003).

ent (2003) find that Canadian interest rates level react more to Canadian key macroeconomic and monetary announcement news during the period following the adoption of immediate diffusion of the Canadian monetary policy decisions since 2000. On the other hand, several authors analyzed the impact of a greater transparency on the accuracy of market forecasts of central bank policy rate decisions (Tabellini, 1987; Dotsey, 1987; Rudin, 1988; Blinder, 1998; Kuttner, 2001; Haldane and Read, 2000; Poole *et al.*, 2002; Lange *et al.*, 2003; Poole and Rasche, 2003; Swansson, 2004). More recent work has shown that the changes in Federal Reserve disclosure policies in 1994 have increased predictability (Kuttner, 2001; Poole *et al.*, 2001; Lange *et al.*, 2003).

In addition to the effect on interest rate levels, a greater transparency can also affect the impact of news related to monetary policy on interest rate volatility. Indeed, higher transparency enables to improve market operators knowledge about monetary policy conduct and enhances the credibility of the central bank. This, in turn, decreases the heterogeneity of agents expectations about future policy decisions and future evolution of target variables. In the end, it should reduce the uncertainty related the central bank monetary policy. However, in the empirical literature, there is very little direct evidence of the impact of a greater transparency on interest rate volatility response to key macroeconomic and monetary announcement news (Chadha and Nolan, 2001; Lee, 2002, 2006). Lee (2002, 2006) considers the effect of a greater transparency on the impact of central bank rate changes on market rate volatility. As for Chadha and Nolan (2001), they analyze the effect of central bank target news and unexpected monetary policy rate changes on market rate volatility. Specifically, these authors study the impacts of numerous changes in English monetary policy conduct on the reaction of short-term interest rate volatility to announced decisions of the Bank of England about its rate and to publications of the minutes of the Monetary Policy Committee (MPC) meetings as well as to the publications of the quarterly Inflation Report.

While financial market volatility plays an important role in understanding how financial instruments are priced, most of the existing studies focus solely on the effect of a greater transparency on the reaction of interest rate levels to news related to monetary policy. This paper aims at contributing to the existing literature by investigating whether and how the change in FOMC disclosure policy introduced in February 1994 affects U.S interest rate level and volatility response to news related to FED policy. It also investigates whether a greater transparency reduces financial market uncertainty and improves predictability. For the present analysis, two kinds of daily interest rate series (3 and 6 months

rates and 3, 5, 7 and 10 years rate) and several macroeconomic news related to FED target variables were used. Macroeconomic news include FED target variables and the official interest rate decisions about U.S. monetary policy. Interest rate dynamics are evaluated with an EGARCH model, as proposed by Nelson (1991). This model enables to take into account the conditional heteroscedasticity effect, asymmetric effects and have the advantage of not having to impose positively restrictions on the coefficients in the conditional volatility equation. To take into account the impact of the new transparency measure, interest rates dynamics are evaluated for the sub-periods preceding and following January 1994. Such an approach per sub-periods was used by the majority of the authors analyzing the impact of monetary policy rate changes on rates dynamics by taking into account new measurements of transparency and/or credibility (see for example Urich and Wachtel, 2001; Chadha and Nolan, 2001; Clare and Courtenay, 2001; Lee, 2002; Parent, 2003).

The paper proceeds as follows. Section 2 presents how a new transparency measure influences the response of interest rate level and volatility to central bank target variables news and to monetary policy decisions. It also put in evidence that the ability of financial markets to anticipate FOMC policy changes improved after 1994. Section 3 presents the data used for the analysis. In section 4, the examination of the data suggests that the ability of financial markets to anticipate FOMC policy decisions changes improved after 1994. Section 5 presents the model used to evaluate the response of interest rate level and volatility to macroeconomic and monetary news (model EGARCH). Section 6 analyzes the results, and finally, section 7 concludes.

2 How can a greater transparency affect the interest rate response to news?

In countries in which central bank reaction functions are well-understood, unexpected macroeconomic announcements should enable to anticipate accurately monetary policy rate changes. Thus in this case only central bank target variables news should influence the dynamics of market interest rate. In contrast, in countries where the conduct of monetary policy is less well-understood, one would expect the reverse. More precisely, in this last case, interest rate dynamics do not react only to news on central bank target variables but also to unexpected part of policy rates. In sum, the response of market interest rate level and volatility to news on central bank target variables and to policy rate

changes strongly depends on central bank's transparency and credibility (Haldane and Read, 1999; Ellingsen and Söderström, 2001; Gravelle and Moessner, 2001; Parent, 2003; Coppel and Connolly, 2003). It follows that a new transparency measure should affect the reaction of market interest rate level and volatility to news about monetary policy. The mechanism through which the new transparency measure works is presented in what follows.

2.1 Impacts on interest rates response to central bank target variables news

A new transparency measure influences both directly and indirectly the response of interest rate level and volatility to central bank objective variables news. The direct effect works through an increase in the transparency of the central bank. As for the indirect effect, it is related to a positive impact of higher transparency on the central bank credibility.

According to Winkler (2000), if a new transparency measure is clearly, honestly and efficiently communicated to the public, then it should increase the transparency degree of central bank improving the understanding of the monetary policy conduct by financial agents. This implies that the markets will react more fully to macroeconomic announcements that are relevant to the monetary policy reaction function. Thus, in a world in which the central bank's reaction function is better known by market participants, one would observe less financial asset price reactions to changes in monetary policy, but significant reactions to the release of surprise macroeconomic data that occur before the monetary policy action date (Haldane and Read, 1999; Ellingsen and Söderström, 2001; Gravelle and Moessner, 2001; Chadha and Nolan, 2001; Clare and Courtenay, 2001a, 2001b; Parent, 2003; Coppel and Connolly, 2003).

In addition, a more transparent monetary policy enhances central bank credibility, reputation and flexibility (Saxton, 1997; Geraats, 2000; Faust and Svensson, 2001; Cukierman, 2001; Jensen, 2002[5], Geraats *et al.* (2006))[6]. Those

[5] In Jensen's (2002) model increased transparency will increase the reputational costs of deviations from the inflation target and therefore increase the credibility of the central bank.

[6] According to Saxton (1997), Geraats (2000), Faust and Svensson (2001), Cukierman (2001) and Geraats *et al.* (2006), the advantages of a greater transparency on credibility, reputation and flexibility derive from the fact that transparency eases the private sector to infer central bank's intentions regarding monetary policy decisions. This allows a central bank to improve its credibility. It also gives the central bank a greater incentive to build reputation as private sector inflation expectations become more sensitive to monetary policy decisions and outcomes that are not attributed to economic shocks. At the same time, transparency makes it clear when monetary policy decisions are intended to offset economic shocks, so it

advantages of transparency should allow to deliver greater overall policy outcomes[7], to reduce monetary policy uncertainty, to decrease heterogeneity in agents' expectations, and to lower the risk premium related to future inflation and interest rates level (Geraats *et al.*, 2006)[8]. More precisely, an improved credibility and reputation enables investors' expectations to adjust faster to central bank target variables news announcements, to reduce inflation expectations and to decrease the heterogeneity of those expectations. Thus, enhanced flexibility, reputation and credibility implied by a greater transparency should increase the response of interest rates levels to central bank target variables news.

As financial market agents become better informed and because their expectations are more homogeneous a greater transparency should reduce financial market volatility (Saxton, 1997; Chadha and Nolan, 2001; Rafferty and Tomljanovich, 2002). A larger amount of relevant information about monetary policy conduct enables private sector expectations to adjust faster to macroeconomic and monetary variables announcement and to reduce uncertainties, decreasing thus market volatility. With a consequent reduction in uncertainty, interest rates volatility will react less to announcements on central bank target variables.

Empirical literature provides little direct evidence of the impact of a greater transparency on interest rate level and volatility response to key macroeconomic and monetary news. Gravelle and Moessner (2001) and Parent (2003) note that such news related to the Canadian Central Bank influence more the interest rates level during the period following the adoption of immediate Canadian Central Bank rate disclosure in November 2000. Regarding market volatility, only Chadha and Nolan (2001) analyze the effect of a greater transparency on market volatility response to macroeconomic and monetary news. These authors find that a greater transparency and credibility of the Bank of England

gives the central bank a greater flexibility to stabilize the economy without affecting market operator's inflation expectations.

[7]Several authors find a negative relation between central bank transparency and the level and/or the variability of inflation (Chortareas et al., 2002; Cecchetti and Krause, 2002; Demertzis and Hughes Hallett, 2003; Ball and Sheridan, 2005). All these authors suggest that greater transparency is associated with a reduction in uncertainty about future policy actions and thus with a reduction in the inflation volatility. For instance, Chortareas et al. (2002) examine the association between the cross-country differences in macroeconomic outcomes and the degree of transparency exhibited by monetary policy, measured by the detail with which central banks publish economic forecasts. Their results suggest that a high degree of transparency in economic forecasts is associated with a lower inflation for all countries.

[8]Geraats *et al.* (2006) investigate whether transparency has improved the flexibility and/or reputation of central banks by allowing for lower policy, short and/or long nominal interest rates. Those authors find that increases in transparency tend to be associated with significant reductions in interest rates when controlling for macroeconomic conditions.

have affected short-term interest rate volatility reaction to the announcement monetary policy rate decisions, of the publications of the minutes of the MPC meetings and of the publications of the quarterly Inflation Report.

2.2 Impacts on the interest rates response to central bank decisions

A new transparency measure affects the interest rates level and volatility reaction to changes in monetary policy rate mainly in two ways: first by improving market forecasts of central bank policy decisions and second by enhancing the central bank credibility.

A greater transparency and a better market understanding of policy should improve the accuracy of market forecasts of central bank policy decisions[9], and thereby, it should reduce interest rate responses to monetary policy actions (Sellon and Weiner, 1996; Muller and Zelmer, 1999; Haldane and Read, 2000; Clare and Courtenay, 2001a,b; Urich and Wachtel, 2001; Kuttner, 2001; Coppel and Connolly, 2003). For example, Urich and Wachtel find that, since the FED began to announce the targets (1994), policy changes have had a lesser effect on U.S. interest rates. Haldane and Read (2000) find empirical evidence that the Bank of England efforts for greater transparency have indeed decreased markets reaction to official interest rate changes. In the same direction, Muller and Zelmer (1999) find evidence in Canada that the increase in the national bank transparency level has diminished markets reactions to official monetary policy rate changes.

Enhanced flexibility, implied by a new transparency measure, would also reduce the effect of the policy rate on the market interest rate. In addition, improved reputation would reduce inflation expectations and thereby long-term nominal interest rates. In other words, a greater credibility should reduce the impact of monetary policy rate changes on interest rate. This relation between

[9]Several authors study, both theoretically and empirically, the effect of a new transparency measure on the predictability of central bank decisions (Tabellini, 1987; Dotsey, 1987; Rudin, 1988; Blinder, 1998; Kuttner, 2001; Haldane and Read, 2000; Winkler, 2000; Poole *et al.*, 2002; Lange *et al.*, 2003; Poole and Rasche, 2003; Swansson, 2004). For example, Haldane and Read (2001) found that the introduction of inflation targeting in the United Kingdom appears to have coincided with a marked dampening in yield curve responses, suggesting greater transparency and predictability as the Bank of England monetary framework changed. For the United States, Urich and Wachtel (2001), Poole and Rasche (2003), Lange *et al.* (2003) and Swansson (2004) demonstrated that FED decisions predictability increased after the 1994 decision to announce changes in FED policy rates immediately after FOMC meetings.

transparency, flexibility and reputation as well as credibility and inflation expectations can explain the result obtained by Haldane and Read (1999). These authors show that after the introduction of inflation targeting in the United Kingdom in November 1992[10] English interest rates react less to monetary policy decisions. Furthermore, since the beginning of 1993, detailed economic analysis and inflation projections are published in the quarterly *Inflation Report*.

A new transparency measure should also reduce the delayed market response and, thereby, increase immediate responses to policy changes. For example, Urich and Wachtel show that after the FED began to announce immediately its decision about its interest rate in 1994, U.S. interest rate began to react more quickly to changes in monetary policy rate. In addition, lower uncertainty and expected heterogeneity due to a greater transparency and credibility should reduce the effect of the diffusion of monetary policy decisions on market volatility. See for exemple, hadha and Nolan (2001), Lee (2002), who analyze the changes in interest rate volatility response to changes in monetary policy rate.

3 Data Description and Preliminary Tests

This section presents the dataset and its statistical properties. The empirical part uses data series on interest rates, macroeconomic announcements and unexpected variations of key interest rates.

3.1 Interest rates series

Two kinds of daily interest rate series are considered: a short term rate (Treasury bills) and a Government bond rate corresponding to maturities of respectively 3 and 6 months and 3, 5, 7 and 10 years. These series cover the period ranging from the first of July 1990 to July, 30^{th}, 2004. This data corresponds to the quotes at local time market closure: 17:30 Eastern Standard Time (EST).

In order to determine the order of integration of these series we carry out a series of unit-root tests. Three different kinds of unit-root tests are performed: the standard ADF test, the Zivot and Andrews (1992) test and finally the Seo (1999) test. According to the results of the ADF test, displayed in table 5, we cannot reject the null hypothesis of unit root for any of the four series. These results are confirmed for the Zivot and Andrews test as well as the Seo test. The Seo statistic allows to account for structural changes in the series while the former accounts for the presence of conditional heteroskedasticity.

[10] Chadha and Nolan (2001) argue that in the inflation targeting regime, central banks attempt to establish credibility through transparency.

Indeed, using Box-Pierce, Ljung-Box and LM statistics (see table 6), the null hypothesis of homoskedasticity is rejected at the 5% level for all assets considered in our study. Thus, all interest rate series present a unit root and interest rates differentials will be used in the empirical analysis. These interest rate series are also conditionally heteroscedastic.

3.1.1 Announcements and surprises

According to Balduzzi et al. (1997), it is not the announcement *per se* that is important, but rather the information it conveys to the market participants. Indeed, if announcements only comfort agents in their expectations they will not induce any behavioral changes. Since the aim of this paper is to study the effect of announcements on the dynamics of interest rates, series that reflect unanticipated variations for the relevant series are needed. These "surprises" are defined as the difference between the observed values for the variables and the values that were anticipated. As anticipations cannot be observed directly some approximation are needed. A solution suggests by Balduzzi et al. (1999) is to choose the surveys published by Money Market Service (MMS) for US macroeconomic announcements. This organization collects every Friday forecasts from a panel of market participants for the following week announcements. Median values for each variable were computed. Those values were retained as proxies of market participant expectations.

In more detail, these variables correspond to possible targets for central banks. That is, primarily, news concerning the inflation rate and the global health of the economies considered. The considered announcements concern unemployment (UE), consumer price index (CPI), production price index (PPI), gross domestic product (GDP), balance of payment (BP), and retail sales (RET). All these variables are announced around 9:00 a.m.

Concerning the unexpected part of monetary policy decisions, two computation methods have been used in the literature. The first method uses surveys for macroeconomic announcements as previously discussed. The alternative approximates central bank decisions through carefully chosen asset quotations. More precisely, the methodology proposed by Kuttner (2001) suggests that FED future fund prices constitute a suitable proxy for FED expected actions. This latter solution is preferable to the surveys since, as pointed by Ehrmann and Fratzcher (2003), (2005), the weekly frequency of surveys prevents from taking into account most recent expectations. On the other hand, asset prices used in this study are those from the day preceding central bank decisions. Prices

Table 1: Percentage of expected and unexpected FED' rate changes

	January 1990 - January 1994	*January 1994 - June 2004*
Actual Change		
- Expected No Change	55.56%	3.13%
- Expected Change	44.44%	96.88%
Actual No Change		
- Expected Change	0.00%	10.87%
- Expected No Change	100.00%	89.13%
Total		
- Incorrect expectation	21.74%	7.69%
- Correct expectation	78.26%	92.31%

of future contracts on FED funds are a reasonable choice as they meet the requirements put forward by Brooke et al. (2000), namely (i) its maturity is close to that of the key interest rate, (ii) it is a liquid asset and (iii) its maturity is shorter than the time interval between FOMC meetings. Moreover, as shown by Krueger and Kuttner (1996), future prices provide an efficient measure for the FED fund rate forecasts. Indeed, forecast errors are uncorrelated with the other variables observed at the contract's pricing time. Following Kuttner's methodology, we extract the unexpected part of monetary authorities' decisions, considering that this unexpected component is reflected by the difference between the future prices on the announcement day and the day before. More precisely, the relationship between the forecast error ($\Delta r_t^{*,na}$) and the future contract rates can be written as follows:

$$\Delta r_t^{*,na} = \frac{T}{T-\tau}(f_t - f_{t-1}), \tag{1}$$

where f denotes interest rate on the future contract, T is the number of days in the month under consideration and τ is the day of the month.

4 Effects of a greater transparency on the predictability of the FED policy decisions

In order to check whether the new transparency measure adopted by the FED improves the predictability of its decisions, the percentages of the expected and unexpected part of the U.S. monetary policy decisions for the sub-periods preceding and following January 1994 were calculated. According to table 1, since February 1994, period during which the FOMC has refrained from changing

rates between meetings, market participants have been better able to anticipate FOMC decisions. Before this period, when the FOMC changed its target rate more frequently at unscheduled times between meetings compare to the period during which FOMC changed the target at meetings, market participants were less likely to correctly anticipate the FOMC decisions. Indeed, only 78.26% of monetary policy decisions were anticipated before January 1994 compared to 92.31% of decisions that were foreseen after this date. These results reveal that market operators better understand the effective conduct of monetary policy and/or they acknowledge better the credibility of the central bank while comparing to the period prior to January 1994. Similar results are obtained by Poole and Rasche (2000, 2001, 2003), Urich and Wachtel (2001) and Lange *et al.* (2003).

In addition, the immediate diffusion of FOMC policy since January 1994 should affect interest rate responses to economic and monetary news. To assess this impact, the model in the next section describes the news influence on the interest rates conditional mean and volatility.

5 The Econometric Model

According to the unit-root test in Section 2, the interest rates first-differenced response to macroeconomic and policy news has been modelised as follows:

$$\Delta R_t = a + b\Delta R_{t-1} + c\Delta r_t^* + \sum_{k=1}^{K} d_k D_{k,t}^a + \sum_{j=1}^{3} e_j JS_t + \epsilon_t, \qquad (2)$$

where R_t denotes the U.S. interest rates differentials in period t. Δr_τ^* and $D_{k,t}^a, k = 1, \ldots, K$ correspond respectively to the unexpected part of the monetary policy rate and to a set of U.S. macroeconomic news. c and d_k measure the effect of these news on the interest rate level. As macroeconomics variables are announced around 9 a.m and the FED diffuses its rate decisions about 2:30 p.m. then Government bond rates in period t respond to macroeconomic news and monetary policy decisions announced on the same day (period t). In addition to macroeconomic and policy news, three days of the week are take into account; namely Monday (Mo), Wednesday (We) and Friday (Fr).

The term ϵ_t corresponds to the innovation series. Several authors estimate equation (2) supposing that the innovations are a Gaussian white noise (Balduzzi *et al.*, 1999; Bernhardsen, 2000; Ellingsen and Söderström, 2001; Favero, 2001; Kearney, 2001; Caporale and Williams, 2002; Parent, 2003). In the same line, equation (2) was estimated, first by supposing that the innovations are a

Gaussian white noise and Engle Arch LM statistics was then applied to check whether the innovations ϵ_t are conditionally homoscedastic. Table 7, in the Appendix, enables to reject the null hypothesis and then accept the hypothesis that the interest rates volatility is conditionally heteroscedastic. Since Bollerslev proposed the GARCH models in 1986, numerous authors used such model to take into account the persistence in conditional variances of financial market. In a GARCH model, an unanticipated drop and an unanticipated rise in the same magnitude in an interest rate are assumed to generate the same impact on its future volatility. However, authors like Kim and Sheen (2000), Lee (2002) and Ehrmann and Fratzscher (2002, 2003, 2005)), argue that the size and the sign of the shocks influence differently the future financial market volatility. On the other hand, DeGoij and Marquering (2006) find that asymmetric volatility in the Treasury bond market can largely be explained by macroeconomic announcement news. This suggests that the asymmetric volatility found in government bond markets is likely due to misspecification of the volatility model. Indeed, after having included macroeconomic announcements into their model, they notice that the asymmetry disappears. In order to take into account the conditional heteroscedasticy effect and to check the asymmetric effect, the exponential GARCH (EGARCH) approach of Nelson (1991) was applied to estimate the effect of macroeconomic and monetary news on the conditional variances of the interest rates. One of the advantages of the EGARCH model is the non imposition of positively restrictions on the coefficients in the conditional variance equation. This model can be expressed as:

$$\begin{aligned} ln(h_t) &= w + \alpha \frac{\epsilon_{t-1}}{\sqrt{h_{t-1}}} + \beta ln(h_{t-1}) + \theta(|\frac{\epsilon_{t-1}}{\sqrt{h_{t-1}}}| - \sqrt{2/\pi}) \\ &+ \gamma Dum_{r^*_\tau} + \sum_{k=1}^{K} \varphi_k Dum^a_{k,t} + \sum_{j=1}^{3} \lambda_j JS_t. \end{aligned} \tag{3}$$

The term α reflects different impacts of positive and negative innovations on conditional variances. A positive (resp. negative) α estimate implies that a positive innovation increases volatility more (resp. less) than a negative (resp. positive) innovation of an equal magnitude. The term θ determines the size effect. As in equation (2), the influence of macroeconomic and policy variables is considered. But dummies instead of actual news were used in order to avoid multicollinearity with the conditional mean regressors.

6 Empirical results

In order to take into account the impact of the transparency measure adopted by the FED in 1994, the interest rate dynamics have been estimated as described by equations (2) and (3) for the sub-periods preceding and following February 1994[11]. The results are presented and discussed in what follows.

6.1 General results

According to table 3, before and after January 1994, U.S. interest rates are mainly sensitive to the consumer price index news (d_{CPI}). In addition, during the first sub-period, short term interest rate level reacts to news relative to economic growth as measured by GDP and retail sales (d_{GDP} and d_{RET}). After 1994, news on unemployment affect medium term interest rates. All the news, except unemployment news, have a positive impact on Treasury bills and Government bonds rates. This is in accordance with theoretical expectancies. Indeed, the CPI can be used as a proxy for the inflation rate. As such, a positive surprise corresponds to an underestimation of the inflation level. In this case, market investors will revise their expectations about FED monetary policy. The negative effect of unemployment news can also be explained if market operators trust monetary policies on their capacity to control inflationary shocks. In other words, they have enough confidence in central bank to achieve its employment target by reducing interest rates without imperilling their inflation objective. Concerning the impact of GDP news, most theories predict that an unexpected increase in real activity and inflation should raise bond yields. More precisely, if increasing economic activity is coupled with higher investment, inducing thus a higher demand for capital, interest rates should rise given a finite elasticity of capital supply. Information about higher economic activity might also change agents' expectations of future inflation rates, as inflation can be spurred by an overheating economy. Therefore, an unexpected increase in real activity could drive interest rates up through higher real rates and/or higher inflation expectations.

As for the unexpected part of FED decisions, they influence positively U.S. interest rates and the amplitude of this effect is increasing with maturity (see

[11] Such an approach per sub-period was used by the majority of the authors analyzing the impact of the monetary policy rate change on the dynamics of the rates by taking account of new measurements of transparency and/or credibility of the central bank (Urich and Wachtel, 2001; Chadha and Nolan, 2001; Clare and Courtenay, 2001a,b; Lee, 2002). It was also used by Parent (2003), who studies the impact of the shocks of the variables relating to the Canadian monetary policy on the level of the rates of the market.

Table 3) (c). This positive effect has already been shown by empirical studies such as Cook and Hahn (1989), Kuttner (2001), Kim and Sheen (2000) or Lee (2002). Cook and Hahn are the first to establish a positive empirical relationship between central bank rates and long term rates. They argue that their results support the expectations theory of the term structure[12]. Table 3 points out an important decrease in U.S. interest rate reaction to unexpected policy decisions after 1994. Indeed, the unexpected policy decisions influence all interest rates before 1994. In contrast, after 1994, only two interest rates react to policy decisions. In addition, the overall size of interest rate response to unexpected changes in the FED rate tends to diminish after 1994. To illustrate this effect, the 6-month interest rate reaction to unexpected policy decisions was 0.6423 before 1994 whereas this reaction falled down to 0.3532 after 1994.

On the volatility side, Table 4 shows that prior to 1994, the unemployment and the consumer price index together with the gross domestic product rate announcement days are the principal variables which affect and amplify interest rate volatility (φ_{UE}, φ_{CPI} and φ_{GDP}). In contrast, after 1994, U.S. interest rate volatility is no longer affected by the announcement days of FED objective variables. Concerning the effect of the diffusion of FED decisions, the results are somewhat different. Indeed, posterior to 1994, the announcement days of the policy decisions amplify more the interest rate volatility compares to the preceding period (see Table 4) (γ). Specifically, in the first sub-period, these announcement days influence only the 3-month U.S. interest rate volatility. In contrast, after 1994, the diffusion of the FED decisions affects positively the volatility of all interest rates. The results obtained for the second sub-period are in accordance with the results obtained by Lee (2002). This author finds that in the most recent period there is larger correlation between U.S. interest rate volatility and fund rate target changes.

In contrast with the results obtained by DeGoij and Marquering (2006), incorporating macroeconomic announcements into the model does not eliminate the asymmetry in the EGARCH model. Indeed, Table 4 shows that during the first sub-period, positive and negative innovations do not have the same impact on conditional variances (α). More precisely and as expected, a positive (resp. negative) innovation increases volatility more (resp. less) than a negative (resp. positive) innovation of an equal magnitude. In contrast, on the second sub-period, the size of the innovations has a large impact on the conditional

[12] The expectations theory says that a long term interest rate should be equal to the average of the short term interest rates over the same period of time plus a term premium; thus, an increase in the first couple of short rate should drive up the long rate in a lesser extent. Roley and Sellon (1995) show historical evidence in support of this view.

variance of the interest rate.

It appears that agents seemed to be more sensitive to inflation shocks than to those which affect economic growth and unemployment (GDP, RET, BP, UE) during the both sub-periods. During the first sub-period, there was a greater uncertainty about inflation than about unemployment and growth. During this period, the FED continuously decreased its main interest rate. This decrease had a positive impact on economic growth and then on employment. This policy and another factor enabled to go out recession. According the NBER, U.S. economy went on expansion in March 1991. Contrary, this policy influenced negatively the inflation. Then, the inflation level and the negative impact of the monetary policy rate decrease on the inflation level can explain greater uncertainty concerning the inflation during the first sub-period. Turning now on the second sub-period, the latter was marked by important decrease and increase of the unemployment rate and the consumer price index. Concerning the monetary policy conduct, the FED decreased more their main rate than increased its, enabling US economy to grow. According to NBER, during the second sub-period, the U.S. economy was an expanding path, except from March to November 2001.

6.2 Transparency and credibility of the FED - Discussion

The result that the effects of the FED target variables announcements on U.S. interest rate volatility decrease in the second sub-period verifies the theoretical implications about the effects of a new transparency measure. Indeed, according section 2, in the period following the implementation of the a transparency measure, interest rate volatility should be less influenced by announcements on macroeconomic and monetary variables. Similarly, the decrease of unexpected changes in FED rates on the interest rate level suggests an increase in its transparency and/or credibility. As mentioned in section 2, a new transparency measure influences the reaction of the interest rate to changes in monetary policy decisions by improving market forecasts of FED decisions and by enhancing its credibility. The first link assumes that a new transparency measure enhances the accuracy of the financial agents forecasts on changes in FED decisions, reducing the impact of these decisions on interest rate levels. However, this impact is already embedded in this analysis since the unexpected part of U.S. monetary policy rates has been taken into consideration. According to the second link, a greater transparency enables to improve market knowledge about monetary policy. In addition, it can enhance the FED's credibility. Thus, both these consequences of a greater transparency can explain the reduction of market rate

reaction to unexpected policy rate decisions. This explanation is more plausible than the first one, which rests on the predictability of FED decisions.

On the contrary, a higher effect of the diffusion of the FED decisions on the interest rate volatility suggests that FED transparency, more particularly its credibility, decreased after 1994. Indeed, in theory, there exists a negative relation between the degree of credibility and the size of the impact of the day on which central bank decisions are diffused on market volatility. Although these results may seem surprising, two types of explanations can be provided. The first rests on the question of the effect of a new transparency measure on the credibility degree. According to the literature, a higher transparency improves the central bank credibility (Faust and Svensson (2001), Cukierman (2001), Geraats *et al.* (2006)). This assumes that any type of transparency measure incites monetary authorities to respect their objectives. However, the diffusion of the FED decisions immediately after each FOMC meeting, frequently at schedule time, does not provide any incentive for the FED to respect its objective[13]. In sort, the immediate diffusion of the FED decisions cannot be considered as a transparency measure that improves the central bank credibility. In addition, basing on Cukierman and Meltzer (1986) methodology[14,15], the constructed credibility index (see Table 2) shows that credibility of FED increases since 1990. As for the third explanation, the effect of central bank rate changes on market volatility does not only depend on the central bank transparency and credibility but also on other factors, such as the degree of financial instability. Authors like Banerjee (1992), Bikchandani *et al.* (1992), McQueen and Roley (1993), Fleming and Remolona (1997), Veronesi (1999) show that the main macroeconomic and monetary news strongly influence market operators behaviour during not only monetary policy uncertainty but also during financial instability. Thus, without questioning the credibility of the FED, various financial crises occurring after 1994[16] may have created uncertainty on financial

[13] In contrast, if the FED decides to publicly announce, for example, the weights put on inflation and on economic growth then this measure can improve the its credibility. The case of the United Kingdom is also a good illustration. The Bank of England switched to a more open framework in 1992, pointing out to a need to enhance the credibility of monetary policy. Since 1992, regular policy meetings have been held between the Government of the Bank of England and Chancellor of the Exchequer, with the minutes of these meetings released to the public within six weeks. In addition, an Inflation Report including economic data and forecasts is published quarterly (King, 1997).

[14] In the literature, the most frequently used methodology to construct credibility index is the methodology proposed by Cukierman and Meltzer (1986) (Faust and Svensson, 1998; Hutchison and Walsh, 1998; Cecchetti and Krause, 2002).

[15] Cukierman and Meltzer (1986) methodology is presented in Appendix.

[16] Examples of crises are the U.S. Government bond crisis (January 1994), the Mexican crisis

Table 2: FED's credibility degree (%)

1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
0.81	0.88	0.94	0.95	0.97	0.96	0.95	0.98	1.00	0.99	0.92	0.96	1.00	0.99	0.96

markets. This in turn, explains the greater impact of the FED decisions on U.S. interest rates volatility.

(December 1994), the Asian crisis (July 1997), the Russian crisis (August 1998), the Brazilian crisis (January 1999) or the Argentina crisis (November 2001).

Table 3: Estimation results (interest rate mean)

	3-month	6-month	3-year	5-year	7-year	10-year	3-month	6-month	3-year	5-year	7-year	10-year
a	-0,0012	**-0,0033***	-0.0049	**-0.0055***	**-0.0052***	-0.0038	**-0,0036***	0,0003	-0.0031	-0.0029	**-0.0036****	**-0.0035****
	(−0,62)	(−2,10)	(−1.85)	(−2.11)	(−2.00)	(−1.50)	-4,13	0,28	(−1.66)	(−1.54)	(−1.93)	(−1.93)
b	-0,00661	**0,0440****	**0.1004***	**0.0758***	**0.0835***	**0.0791***	**0,0391****	0,0334	**0.0484***	**0.0514***	**0.0481***	**0.0462***
	(−0,21)	(1,85)	(3.34)	(2.66)	(2.84)	(2.74)	1,78	1,45	(2.64)	(2.75)	(2.50)	(2.52)
d	**0,6135***	**0,6423***	**0.3323***	**0.2360***	**0.2129***	**0.1716****	0,1680	**0,3532***	**0.1908***	0.0979	0.0334	0.0089
	(4,98)	(5,95)	(2.32)	(2.08)	(1.97)	(1.68)	1,53	2,50	(2.58)	(1.03)	(0.36)	(0.10)
d_{UE}	-0,0540	-0,0731	-0.1013	-0.0755	-0.0698	-0.0501	-0,0590	-0,0394	**-0.1326****	**-0.1301****	-0.1095	-0.1050
	(−0,96)	(−1,46)	(−1.14)	(−0.90)	(−0.93)	(−0.74)	-1,59	-1,60	(−1.92)	(−1.82)	(−1.56)	(−1.55)
d_{CPI}	**0,0521****	**0,0847***	**0.1959***	**0.1753***	**0.1623***	**0.1663***	**0,0598***	0,0144	**0.1522***	**0.1315***	**0.1241***	**0.0918****
	(1,72)	(2,79)	(2.63)	(2.02)	(2.02)	(2.39)	2,05	0,54	(2.88)	(2.36)	(2.10)	(1.66)
d_{PPI}	0,0110	0,0095	0.0137	0.0045	0.0069	0.0222	-0,0147	-0,0016	-0.0249	-0.0266	-0.0285	-0.0217
	(0,46)	(0,61)	(0.40)	(0.12)	(0.18)	(0.52)	-1,15	-0,15	(−1.22)	(−1.25)	(−1.42)	(−1.10)
d_{GDP}	**0,0223***	**0,0166****	0.0197	0.0184	0.0166	0.0156	**0,0094***	0,0048	0.0028	0.0013	0.0009	0.0002
	(2,12)	(1,93)	(1.24)	(1.01)	(0.94)	(1.05)	2,17	0,93	(0.23)	(0.10)	(0.08)	(0.01)
d_{RET}	**0,0228***	**0,0146****	**0.0351***	0.0252	0.0177	0.0148	**0,0217***	0,0150	0.0320	0.0290	0.0291	0.0288
	(2,32)	(1,81)	(1.97)	(1.21)	(0.84)	(0.76)	1,87	1,39	(1.47)	(1.34)	(1.44)	(1.51)
d_{BP}	-0,0027	0,0017	-0.0089	-0.0046	-0.0047	-0.0011	0,0000	-0,0008	0.0006	0.0003	0.0019	0.0012
	(−0,58)	(0,51)	(−1.53)	(−0.76)	(−0.78)	(−0.19)	0,02	-0,67	(0.25)	(0.15)	(0.76)	(0.52)
e_{MON}	**0,0075***	**0,0091***	**0.0097***	0.0070	0.0050	0.0042	**0,0176***	**0,0049***	**0.0092***	**0.0084***	**0.0080***	**0.0085***
	(2,54)	(3,54)	(2.30)	(1.63)	(1.18)	(1.00)	12,48	2,86	(3.21)	(2.89)	(2.77)	(3.14)
e_{WE}	**-0,0126***	**-0,0109***	0.0007	0.0031	0.0033	0.0010	-0,0020	**-0,0063***	0.0020	0.0010	0.0024	0.0015
	(−4,84)	(−4,63)	(0.18)	(0.75)	(0.82)	(0.26)	-1,42	-3,45	(0.67)	(0.31)	(0.78)	(0.50)
e_{FRI}	-0,0025	-0,0022	0.0080	**0.0131***	**0.0113***	0.0086	0,0023	-0,0016	-0.0007	-0.0001	0.0007	0.0010
	(−0,77)	(−0,72)	(1.57)	(2.62)	(2.37)	(1.88)	1,43	-1,03	(−0.21)	(−0.03)	(0.20)	(0.29)

Notes: The values in (.) are the t-statistics proposed by Bollerslev and Wooldridge (1992)**?**.

* and ** indicate that the corresponding coefficient is statistically significant at the 5% and 10 % level, respectively.

$\Delta R_t = a + b\Delta R_{t-1} + c\Delta r_t^* + \sum_{k=1}^{K} d_k D_{k,t}^a + \sum_{j=1}^{3} e_j JS_t + \epsilon_t$

UE: unemployment; CPI: consumer price index; PPI: producer price index, RET: retail sales; BP: GDP: gross domestic product

Table 4: Estimation results (interest rate volatility)

	3-month	6-month	3-year	5-year	7-year	10-year	3-month	6-month	3-year	5-year	7-year	10-year
w	**-0,6244***	0,1753	**-2.0468***	**-5.6507***	**-6.0486***	**-6.2927***	-0,1054	**-0,2717***	0.1075	0.1130	0.0684	0.0319
	(−2,73)	(1,16)	−3.35)	(−5.30)	(−4.75)	(−3.76)	(−0,76)	(−2,22)	(1.08)	(1.10)	(0.67)	(0.30)
θ	**0,2508***	-0,0009	**0.1950***	0.0587	0.0753	-0.0270	**0,2240***	**0,2841***	**0.0759***	**0.0793***	**0.0799***	**0.0767*)**
	(4,16)	(−0,04)	(2.45)	(0.61)	(0.73)	(−0.28)	(9,33)	(8,22)	(3.92)	(4.09)	(4.40)	(3.85)
α	-0,0503	**-0,0400***	**0.1046****	**0.1302***	**0.1409***	**0.1051****	-0,0264	**-0,0587****	-0.0116	-0.0083	-0.0021	0.0060
	(−1,10)	(−2,74)	(1.87)	(2.08)	(2.28)	(1.77)	(−1,28)	(−1,92)	(−0.88)	(−0.57)	(−0.14)	(0.39)
β	**0,9075***	**0,9989***	**0.6633***	0.0527	-0.0061	-0.0537	**0,9711***	**0,9636***	**0.9833***	**0.9770***	**0.9731***	**0.9654*)**
	(31,26)	(338,99)	(6.86)	(0.30)	(−0.03)	(−0.20)	(122,28)	(104,02)	(149.70)	(122.17)	(112.69)	(90.07)
γ	**0,9463***	-0,0795	0.3484	0.4626	0.4574	0.4686	**0,5182***	**1,0940***	**0.2920***	**0.3546***	**0.3745***	**0.4502*)**
	(2,94)	(−0,71)	(0.86)	(1.61)	(1.42)	(1.45)	(2,22)	(2,18)	(2.40)	(2.88)	(2.92)	(3.33)
φ_{UE}	**0,7072***	0,4593	**0.8695***	**1.0898***	**1.0100***	**0.9042***	**0,3246****	-0,2732	0.1039	0.1838	0.1777	0.1856
	(2,29)	(1,60)	(3.37)	(4.66)	(4.84)	(4.21)	(1,69)	(−1,39)	(0.59)	(1.03)	(1.02)	(1.05)
φ_{CPI}	-0,2834	-0,4092	0.1197	**0.4794****	**0.4391****	**0.3809****	0,0423	0,0718	-0.0536	-0.0512	-0.0840	-0.0342
	(−0,93)	(−1,53)	(0.42)	(1.81)	(1.70)	(1.69)	(0,26)	(0,33)	(−0.39)	(−0.39)	(−0.62)	(−0.26)
φ_{PPI}	-0,0423	-0,2281	-0.0294	0.2453	**0.4070***	**0.5357***	-0,2613	0,0318	-0.0911	-0.1972	-0.2036	-0.1936
	(−0,18)	(−1,52)	(−0.11)	(1.17)	(1.94)	(2.50)	(−1,27)	(0,15)	(−0.56)	(−1.18)	(−1.17)	(−1.12)
φ_{GDP}	0,3047	-0,0536	**0.8044***	**0.6383***	**0.6040***	**0.5283***	0,1328	**0,4539***	0.2069	0.1485	0.1188	0.0722
	(1,33)	(−0,17)	(2.97)	(3.62)	(3.33)	(2.79)	(0,71)	(2,23)	(1.23)	(1.01)	(0.78)	(0.48)
φ_{RET}	-0,0704	0,3362	0.0811	0.3262	0.3905	0.2622	-0,1182	0,0291	-0.0002	0.0735	0.0699	0.0170
	(−0,19)	(1,33)	(0.30)	(1.48)	(1.81)	(1.32)	(−0,54)	(0,12)	(0.00)	(0.42)	(0.38)	(0.09)
φ_{BP}	**0,8664***	**0,9016***	0.1863	0.0793	0.1125	0.1120	-0,2325	-0,0631	-0.0873	-0.0995	-0.0384	-0.0724
	(4,27)	(3,31)	(0.76)	(0.30)	(0.44)	(0.50)	(−1,43)	(−0,32)	(−0.72)	(−0.82)	(−0.31)	(−0.58)
λ_{MON}	-0,3203	**-0,6574***	**-0.4796***	-0.0781	-0.0738	-0.0117	**-0,4927***	0,0313	**-0.8646***	**-0.9540***	**-0.9079***	**-0.9521*)**
	(−1,30)	(−2,39)	(−2.05)	(−0.41)	(−0.45)	(−0.07)	(−2,75)	(0,14)	(−4.99)	(−5.83)	(−5.56)	(−5.93)
λ_{WE}	**-0,8286***	**-0,6481***	**-0.3785****	**-0.3181****	**-0.3253***	**-0.3467***	**-0,5736***	**-0,6725***	**-0.3605****	**-0.4163***	**-0.3969***	**-0.3623*)**
	(−2,59)	(−1,96)	(−1.80)	(−1.90)	(−2.15)	(−2.15)	(−2,95)	(−3,12)	(−1.79)	(−2.28)	(−2.23)	(−2.07)
λ_{FRI}	-0,0805	0,1693	0.0653	0.0504	-0.0531	-0.0835	-0,2157	-0,3091	-0.0992	-0.1689	-0.1233	-0.1430
	(−0,33)	(0,58)	(0.34)	(0.34)	(−0.38)	(−0.54)	(−1,03)	(−1,53)	(−0.64)	(−1.15)	(−0.88)	(−1.03)

Notes: The values in (.) are the t-statistics proposed by Bollerslev and Wooldridge (1992)**?**.

* and ** indicate that the corresponding coefficient is statistically significant at the 5% and 10 % level, respectively.

$ln(h_t) = w + \alpha \frac{\epsilon_{t-1}}{\sqrt{h_{t-1}}} + \beta ln(h_{t-1}) + \theta(|\frac{\epsilon_{t-1}}{\sqrt{h_{t-1}}}| - \sqrt{2/\pi}) + \gamma Dum_{r^*_\tau} + \sum_{k=1}^{K} \varphi_k Dum^a_{k,t} + \sum_{j=1}^{3} \lambda_j JS_t$

UE: unemployment; CPI: consumer price index; PPI: producer price index, RET: retail sales; BP: ; GDP: gross domestic product

7 Conclusion

This paper investigates the impact of a higher transparency on financial market reaction where the FED's decisions of immediate diffusion of its policy rate after each FOMC meeting held regularly at scheduled time is interpreted as a measure of transparency. Specifically, the effect of this new transparency measure has been analysed on both reaction of U.S. Treasury rate and Government bond rate level and volatility to news related to the FED's policy. These news correspond to FED's target variables and to unexpected changes of policy rates. How a greater transparency influences the predictability of the FED's rate has also been analysed. The results obtained suggest that, since February 1994, period where the FOMC has refrained from changing rates between meetings, market participants have been able to anticipate better the FOMC decisions. Moreover, the new measure adopted by the FED in January 1994, has been clearly and honestly diffused to the public improving its transparency. This observation is in accordance with the argument of Poole and Rasche (2000). Specifically, the authors argue that since February 1994 market participants have a better understanding of the Federal Reserve's monetary policy reaction function. However, this new transparency measure does not seem to have an influence on credibility.

References

Balduzzi, P., Bertola, G. and Foresi, S. (1997), 'A model of target changes and the term structure of interest rates', *Journal of Monetary Economics* **39**(2), 223–249.

Balduzzi, P., Elton, E. and Green, T. (1999), 'Economic news and the yield curve: Evidence from the u.s. treasury market', *New York University, Leonard N. Stern School Working Paper* .

Ball, L. and Sherida, N. (2005), 'Does inflation targeting matter?', *in Ben Bernanke and Michael Woodford (eds), The Inflation-Targeting Debate, Chicago: University of Chicago Press* pp. 249–278.

Banerjee, A. (1992), 'A simple model of herd behavior', *Quarterly Journal of Economics* **107**, 797–818.

Bernhardsen, T. (2000), 'The relationship between interest rate differentials and macroeconomic variables: a panel data study for european countries', *Journal of International Money and Finance* (19), 289–308.

Bikchandani, S., Hirshleifer, D. and Welch, I. (1992), 'A theory of fads, fashion, custom and cultural change as informational cascades', *Journal of Political Economy* **100**, 992–1026.

Blinder, A. S. (1998), 'Central banking in theory and practice', *MIT Press* .

Bollerslev, T. (1986), 'Generalized autoregressive condional heteroskedasticity', *Journal of Econometrics* **31**, 307–327.

Brooke, M., Cooper, N. and Scholtes, C. (2000), 'Inferring market interest rate expectations from money market rates', *Bank of England Quarterly Bulletin* pp. 392–402.

Caporale and Williams (2002), 'Long-term nominal interest rates and domestic fundamentals', *Review of Financial Economics* (11), 119–130.

Cecchetti, S. and Krause, S. (2002), 'Central bank structure, policy efficiency and macroeconomic performance: Exploring the empirical relationships', *The Federal Reserve Bank of St. Louis* (July/August).

Chadha, J. and Nolan, C. (2001), 'Inflation targeting, transparency and interest rate volatility: Ditching 'monetary mystique' in the uk', *Journal of Macroeconomics* **23**(3), 349–366.

Chortareas, G., Stasavage, D. and Sterne, G. (2002), 'Does it pay to be transparent? international evidence form central bank forecasts', *Review, Federal Reserve Bank of St. Louis* (July), 99–118.

Clare, A. and Courtenay, R. (2001*a*), 'Assessing the impact of macroeconomics news annoncements on securities prices under different monetary policy regimes', *Bank of England Working Paper Nř 125* .

Clare, A. and Courtenay, R. (2001*b*), 'What can we learn about monetary policy transparency from financial market data?', *Deutsche Bundesbank Discussion Paper* (06/01).

Cook, T. and Hahn, T. (1989), 'The effect of changes in the federal funds target rate on market interest rates in the 1970s', *Journal of Monetary Economics* **24**, 331–351.

Coppel, J. and Connolly, E. (2003), 'What do financial market data tell us about monetary policy transparency?', *Reserve Bank of Australia Research Discussion Papers* (2003-05).

Cukierman, A. (2001), 'Accountability, credibility, transparency and stabilization policy in the eurosystem', *In Charles Wyplosa ed., The impact of EMU on Europe and the developing Countries, Oxford University Press* **chap. 3**, 40–75.

Cukierman, A. and Meltzer, A. (1986), 'The theory of ambiguity, credibility, and inflation under discretion and asymmetric information', *Econometrica* **54**, 1099–1128.

DeGoeij, P. and Marquering, W. (2006), 'Macroeconomic announcements and asymmetric volatility in bond returns', *Journal of Banking and Finance* **30**, 2659 – 2680.

Demertzis, M. and Hallett, A. H. (2003), 'Central bank transparency in theory and practice,', *DNB Staff Reports, Netherlands Central Bank* (105).

Dotsey, M. (1987), 'Monetary policy, secrecy, and federal funds rate behavior', *Journal of Monetary Economics* **20**, 463–474.

Ehrmann, M. and Fratzcher, M. (2003), 'Monetary policy announcements and money markets: A transatlantic perspective', *International Finance* **6**(3), 309–328.

Ehrmann, M. and Fratzcher, M. (2005), 'Equal size, equal role? interest rate interdependence between the euro area and the united states', *Economic Journal* **115**(506), 930–948.

Ellingsen, T. and Söderström, U. (2001), 'Monetary policy and market interest rates', *American Economic Review* **91**(5), 1594–1607.

Erhmann, M. and Fratzscher, M. (2002), 'Interdependence between the euro area and the us: What role for the emu?', *European Central Bank Working Paper* (200).

et M. Zelmer, P. M. (1999), 'Greater transparency in monetary policy: Impact on financial markets', *rapport technique, Banque du Canada.* (86).

Faust, J. and Svensson, L. (1998), 'Transparency and credibility: Monetary policy with unobservable goals', *NBER Working Paper* .

Faust, J. and Svensson, L. E. (2001), 'Transparency and credibility monetary policy with unobservable goals', *InternationalEconomicReview* **42**(2), 369–397.

Favero (2001), 'Does macroeconomics help us to understand the term structure of interest rates?', *CEPR discussion paper series* (2749).

Fleming, M. and Remolona, E. (1997), 'Price formation and liquidity in the u.s. treasury market: Evidence from intraday patterns around announcements', *Reserve Bank of New York* (27).

Froyen, R. and Waud, R. (1995), 'Central bank independence and the output-inflation tradeoff', *Journal of Economics and Business* **47**.

Geraats, P. M. (2000), 'Why adopt transparency? the publication of central bank forecast', *CEPR Discussion Paper* (2582).

Geraats, P. M., Eijffinger, S. C. W. and van der Cruijsen, C. A. (2006), 'Does central bank transparency reduce interest rates?', *mimeo* .

Goodfriend, M. (1990), 'Interest rates and the conduct of monetary policy', *Working Paper? Federal Reserve Bank of Richmond* (90-06).

Goodhart, C. (1996), 'Why do the monetary authorities smooth interest rates?', *LSE Financial Markets Group Special Paper* (81).

Gravelle, T. and Moessner, R. (2001), 'Reactions of canadian interest rates to macroeconomics announcements: Implications for monetary policy transparency', *Bank of Canada Working Paper* **2001-5**.

Haldane, A. and Read, V. (1999), 'Monetary policy and the yield curve', *Bank of England Quarterly Bulletin* pp. 171–176.

Haldane, A. and Read, V. (2000), 'Monetary policy surprises and the yield curve', *Bank of England Working Paper* (106), 1–41.

Hutchison, M. and Walsh, C. (1998), 'The output-inflation trade-off and central bank reform: evidence from new zealand', *Economic Journal* **108**, 703–725.

Jensen, H. (2002), 'Optimal degrees of transparency in monetary policymaking', *Scandinavian Journal of Economics* **104**, 399–424.

Kearney (2001), 'A note on modeling the impact of economic announcements on interest rates', *Economic letters* (71), 83–89.

Kim, S.-J. and Sheen, J. (2000), 'International linkages and macroeconomic news effects in interest rate volatility - autralia and the us', *Pacific-Basin Finance Journal* **8**(1), 85–113.

King, M. (1997), 'Changes in uk monetary policy: Rules and discretion in practice', *Journal of monetary Economics* (39), 81–97.

Krueger, J. and Kuttner, K. (1996), 'The fed funds futures rate as a predictor of federal reserve policy', *Journal of Futures Markets* **16**, 865–879.

Kuttner, K. (2001), 'Monetary policy surprises and interest rates: Evidence from the fed funds futures market', *Journal of Monetary Economics* **47**(3), 523–544.

Lange, J., Sack, B. and Whitesell, W. (2003), 'Anticipations of monetary policy in financial markets', *Journal of Money* **35**(6), 889–908.

Lee, J. (2002), 'Federal funds target changes and interest rate volatility', *Journal of Economics and Business* **54**(2), 159–191.

Lee, J. (2006), 'The impact of federal funds target changes on interest rate volatility', *International Review of Economics and Finance* **15**, 241–259.

McQueen, G. and Roley, V. (1993), 'Stock prices, news, and business conditions', *Review of Financial Studies* **6**(3), 683–707.

Nelson, D. (1991), 'Conditionnal heteroskedasticity in assets returns : a new approach', *Econometrica* **59**, 347–370.

Parent, N. (2003), 'Transparence et réactin des taux d'intérêt à la publication périodique des données macroéconomiques', *Revue de la Banque du Canada* **Hiver 2002-2003**, 31–37.

Poole, W. and Rasche, R. H. (2000), 'Perfecting the market's knowledge of monetary policy', *Journal of Financial Services Research* **18**, 255–298.

Poole, W. and Rasche, R. H. (2003), 'The impact of changes in fomc disclosure practices on the transparency of monetary policy: Are markets nd the fomc better 'synched", *The Federal Reserve of St. Louis Reviews* pp. 1–10.

Poole, W., Rasche, R. H. and Thornton, D. L. (2002), 'Market anticipations of monetary policy actions', *The Federal Reserve of St. Louis Reviews* **issue Jul.**, 65–94.

Rafferty, M. and Tomljanovich, M. (2002), 'Central bank transparency and market efficiency: An econometric analysis', *Journal of Economics and Finance* .

Roley, V. V. and Sellon, H. (1995), 'Monetary policy actions and long-term interest rates', *Federal Reserve Bank of Kansas City, Economic Review* **fourt quarter**, 73–89.

Rudin, J. R. (1988), 'Central bank secrecy, 'fed watching', and the predictability of interest rates', *Journal of Monetary Economics* **22**, 317–334.

Sack, B. and Wieland, V. (2000), 'Interest rate smoothing and optimal monetary policy: A review of recent evidence', *Journal Economics and Business* **52**, 205–228.

Saxton, J. (1997), 'Transparency and federal reserve monetary policy', *A Joint Economic Committee Study* .

Sellon, G. H. and Weiner, S. E. (1996), 'Monetary policy without reserve requirements: Analytical issues', *Federal Reserve Bank of Kansas City. Economic Review* pp. 5–24.

Seo, B. (1999), 'Distribution theory for unit root tests with conditional heteroskedasticity', *Journal of Econometrics* **91**(1), 113–144.

Swansson, E. T. (2004), 'Federal reserve transparency and financial market forecasts of short-term interest rates', *Federal Reserve Board Finance and Economics Discussion Paper* **2004-6**.

Tabellini, G. (1987), 'Secrecy of monetary policy and the variability of interest rates', *Journal of Money, Credits and Banking* **19**, 425–436.

Urich, T. and Wachtel, P. (2001), 'Financial market responses to monetary policy change in the 1990s', *Contemporary Economic Policy* **19**(3), 254–267.

Veronesi, P. (1999), 'Stock market overreaction to bad news in good times: A rational expectations equilibrium model', *Review of Financial Studies* **12**(5), 975–1007.

Winkler, B. (2000), 'Which kind of transparency? on the need for clarity in monetary policy-making', *European Central Bank Working Paper series* (26.), 1–34.

Woodford, M. (1999), 'Optimal monetary policy inertia', *NBER Working Paper* (7261).

Zivot, E. and Andrews, D. (1992), 'Further evidence on the great crash, the oil-price shock, and unit-root hypothesis', *Journal of Business and Economic Statistics* **10**(3), 251–270.

8 Appendix

Central bank credibility index

Cukierman and Meltzer (1986) authors define monetary policy credibility as "the absolute value of the difference between the policymaker's plans and the public's beliefs about those plans". In this approach, the credibility index can be expressed as:

$$\begin{aligned} Cre &= 1 && if \quad E(\pi) < \pi^t, \\ Cre &= 1 - \frac{E(\pi) - \pi^t}{0.2 - \pi^t} && if \quad \pi^t < E(\pi) < 20\%, \\ Cre &= 0 && if \quad E(\pi) > 20\%. \end{aligned}$$

The more the expected inflation ($E(\pi)$) diverges from the level of the target inflation (π^t), the less credible the central bank is ($Cre \to 0$). In the same vein, if the expected inflation is smaller than or close to the target level of inflation, then the credibility of the central bank attains its maximum value ($Cre \to 1$).

Some authors, as Cecchetti and Krause (2002), while using this approach, supposed the same level for the inflation target for all the countries they retained in their empirical analysis. In addition, they also assume that the expected inflation used in order to construct the credibility index is based on the realized inflation of the previous period. Contrary to these authors, we fix the same inflation target for the industrialized countries and the same target for the emerging countries. For the industrialized countries, we suppose that the inflation target is 2.125[17], which corresponds to the average of the target fix by some central bank of industrialized countries practicing inflation target. As for the emerging countries, we suppose that the inflation target is equal to 3.25[18]. Furthermore, the expected inflation is obtained using data from Datastream.

[17] 2.125 correspond to the average value of the inflation target level fixed by industrial countries, as United Kingdom and Australia, during 90s.

[18] 3.25 correspond to the average value of the inflation target level fixed by emerging countries, as Brazil and Mexico, during 90s.

Table 5: Test of unit root

	ADF					ZandA			SEO		
	Model C		Model B		**Model A**	**Model C**	**Model B**	**Model A**	**Model 2**	**Model 1**	**Model 0**
	$\widehat{\rho}$	$\widehat{\beta}$	$\widehat{\rho}$	$\widehat{\mu}$	$\widehat{\rho}$						
3-month	-4.278	-0.000**	-4.017	0.201**	-1.780**	-3.679**	-2.083**	-4.282**	-0.656**	-0.702**	0.290**
		(0.004)		(3.64)		[10/99]	[02/94]	[03/01]	[0.62]	[0.62]	[0.62]
6-month	-0.885	-0.000**	-0.837	0.000**	-2.572*	-3.623**	-3.582**	-4.192**	-0.233**	-0.021**	-0.672**
		(−0.29)		(0.12)		[08/99]	[01/00]	[03/01]	[0.63]	[0.63]	[0.63]
3-year	-1.811	-0.000**	-1.386	0.002**	-2.450*	-3.152**	-2.964**	-3.194**	-1.302**	-1.716**	-2.145**
		(−1.295)		(0.66)		[03/99]	[01/00]	[02/94]	[0.56]	[0.55]	[0.62]
5-year	-1.858	-0.000**	-1.270	0.002**	-2.202*	-3.434**	-2.885**	-3.284**	-2.136*	-1.847**	-2.072**
		(−1.42)		(0.67)		[03/99]	[01/00]	[02/94]	[0.58]	[0.58]	[0.59]
7-year	-1.958	-0.000**	-1.293	0.003**	-2.135*	-3.848**	-2.881**	-3.312**	-2.259*	-1.983**	-2.401**
		(−1.53)		(0.77)		[02/94]	[01/00]	[02/94]	[0.61]	[0.61]	[0.61]
10-year	-2.642	-0.000**	-1.409	0.007**	-1.538**	-4.106**	-2.923**	-3.405**	-2.024*	-1.419**	-2.159**
		(−2.24)		(1.16)		[02/94]	[03/01]	[02/94]	[0.61]	[0.60]	[0.56]

* and ** indicate that the corresponding coefficient is statistically significant at the 5% and 10 % level, respectively.

The values [./.] in the central part of the table correspond to the month and the year of the change.

The value [.] in the right hand of the table corresponds to the value of ρ.

Table 6: Statistical properties of daily U.S. interest rates

	3-month	6-month	3-year	5-year	7-year	10-year
Lyung-Box (LB) test to the squared residuals						
LB(1)	45.095*	27.299*	3.592**	7.512*	18.264*	7.101*
LB(5)	129.920*	107.380*	40.893*	48.647*	55.437*	47.970*
LB(10)	165.969*	171.265*	63.716*	79.554*	92.816*	85.052*
Box-Pierce (BP) test to the squared residuals						
BP(1)	45.047*	27.270*	3.591**	7.504*	18.244*	7.093*
BP(5)	129.753*	107.205*	40.816*	48.558*	55.345*	47.884*
BP(10)	165.702*	170.916*	63.572*	79.370*	92.611*	84.852*
Box-Pierce statistics applied to the absolute value of residuals						
BP(1)	92.907*	75.259*	6.517*	7.629*	5.452*	3.673*
BP(5)	360.440*	317.698*	89.972*	85.628*	76.874*	68.269*
BP(10)	569.556*	572.175*	137.389*	143.439*	125.578*	115.960*
LM test for ARCH effect						
LM(1)	45.048*	27.279*	3.591*	7.505*	18.483*	7.094*
LM(5)	105.874*	89.727*	38.207*	44.478*	50.226*	43.474*
LM(10)	124.858*	119.002*	52.665*	63.356*	72.962*	65.301*

* and ** indicate that the corresponding coefficient is statistically significant at the 5% and 10 % level, respectively.

Table 7: Statistical properties of innovations (ϵ^1)

	3-month	6-month	3-year	5-year	7-year	10-year
LM test for ARCH effect						
LM(1)	67.333*	24.682*	3.297**	12.704*	23.042*	9.109*
	0.00)	0.00)	(0.07)	(0.00)	(0.00)	(0.00)
LM(5)	144.309*	97.005*	49.927*	56.993*	57.820*	50.075*
	0.00)	0.00)	(0.00)	(0.00)	(0.00)	(0.00)
LM(10)	165.563*	158.863*	71.586*	77.162*	79.297*	72.141*
	0.00)	0.00)	(0.00)	(0.00)	(0.00)	(0.00)

* and ** indicate that the corresponding coefficient is statistically significant at the 5% and 10 % level, respectively.

[1] ϵ correspond to the innovation series in the model described by equation (2).